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(54) **TURBOMACHINE PROBE RETENTION FEATURE**

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(52) **U.S. Cl.**
CPC ***G01B 7/14*** (2013.01); *F05D 2260/80* (2013.01); *Y10T 29/49947* (2015.01); *Y10T 29/49968* (2015.01)

(58) **Field of Classification Search**
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USPC 415/201
See application file for complete search history.

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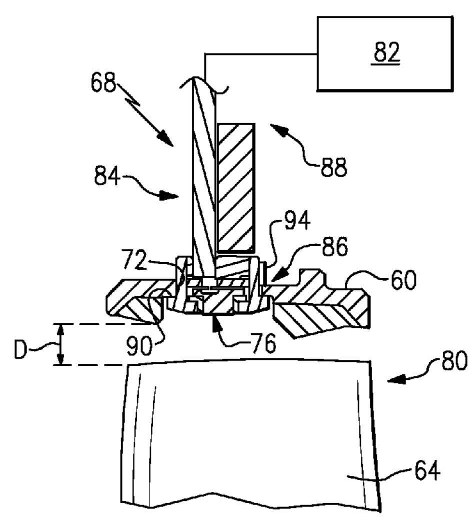
(57) **ABSTRACT**

An example turbomachine probe assembly includes a probe body extending along a probe axis from a first sensor end to an opposing second end. An eccentric retention feature is configured to engage the probe body into contact with wall having an aperture that receives the probe body. The eccentric retention feature limits movement of the probe body along the probe axis relative to the wall.

19 Claims, 6 Drawing Sheets



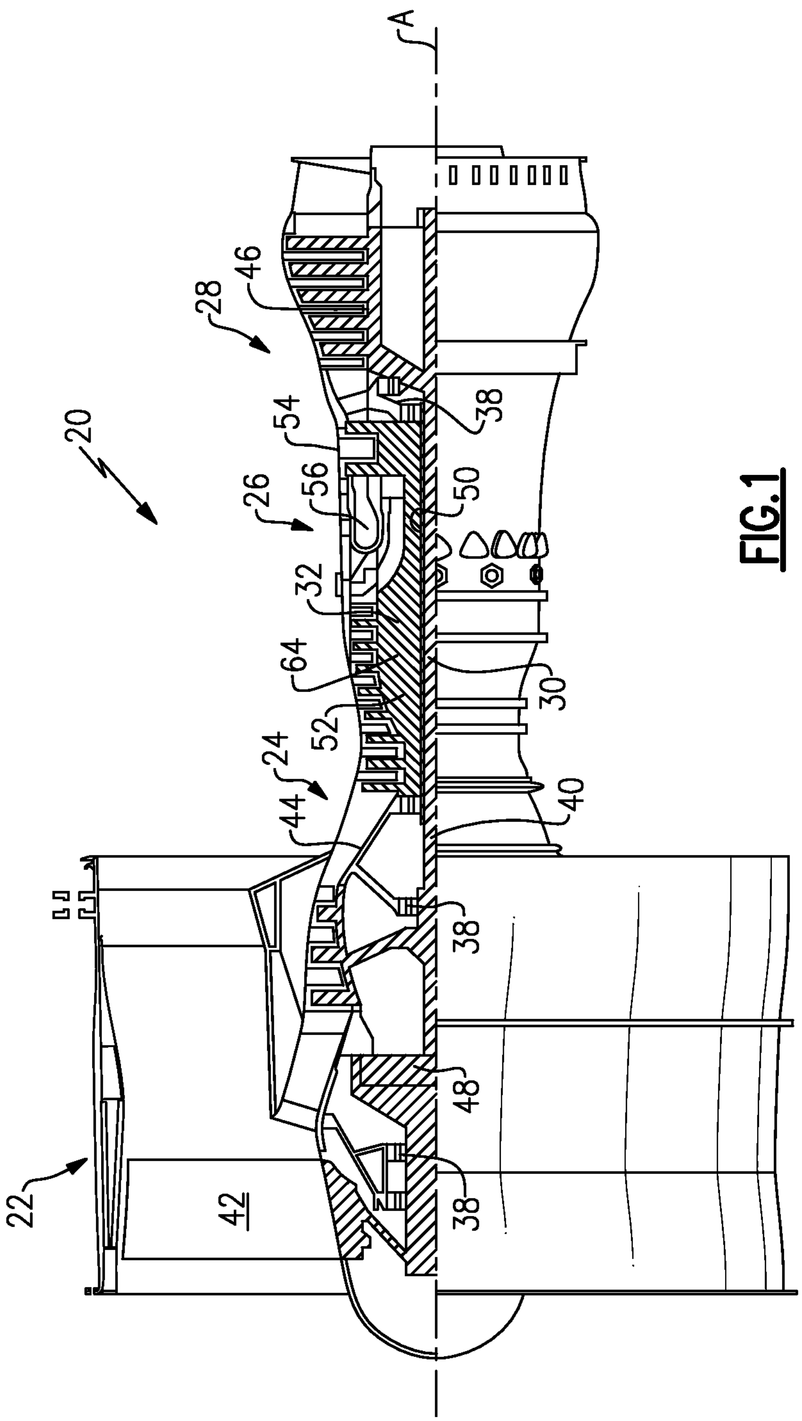


FIG.1

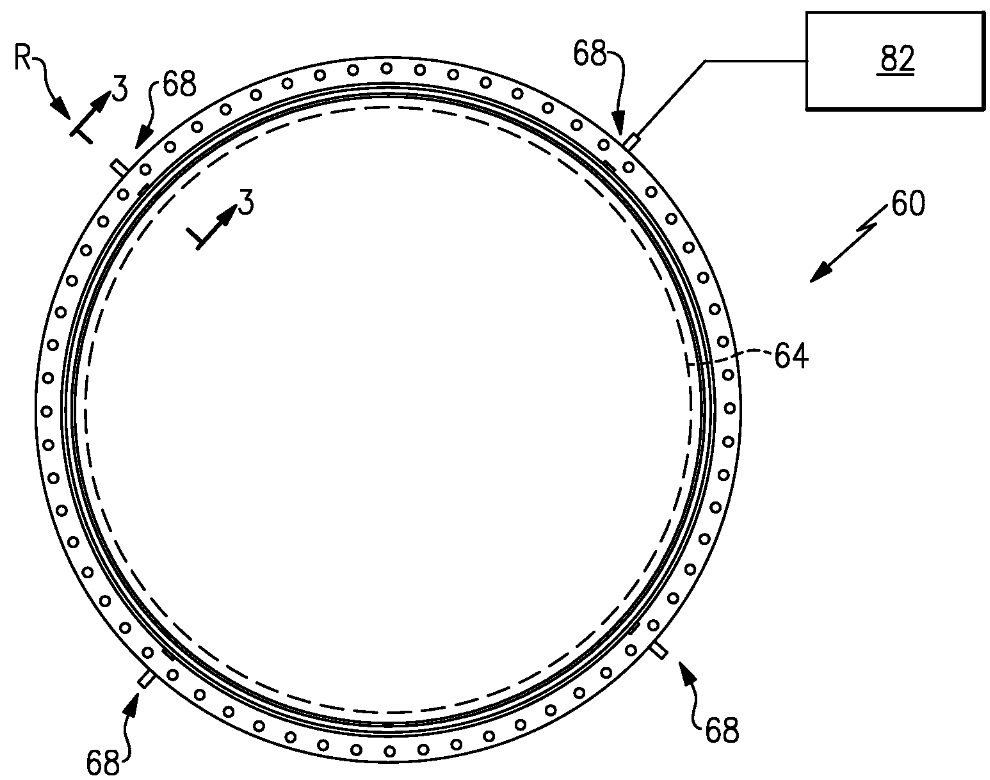


FIG.2

FIG.3

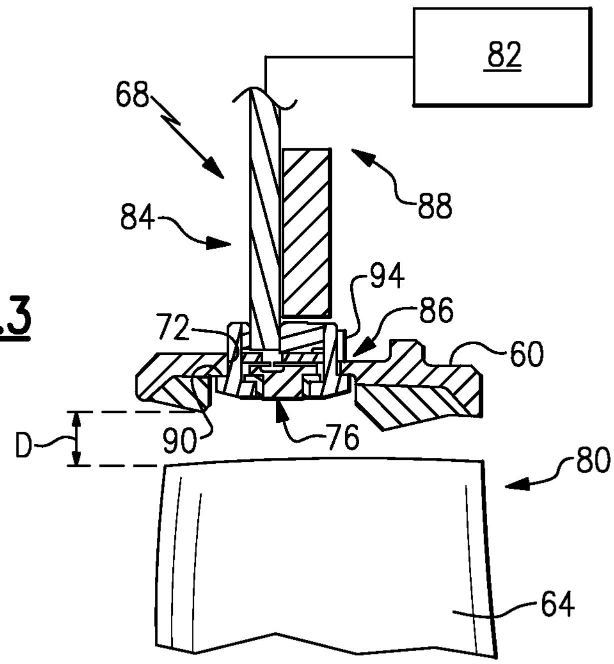


FIG.4

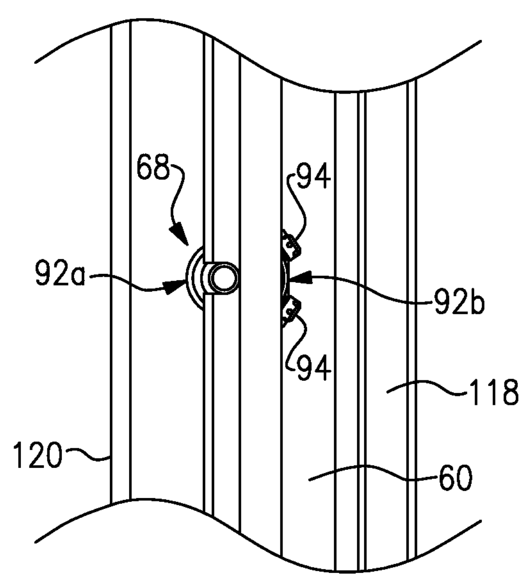


FIG.5

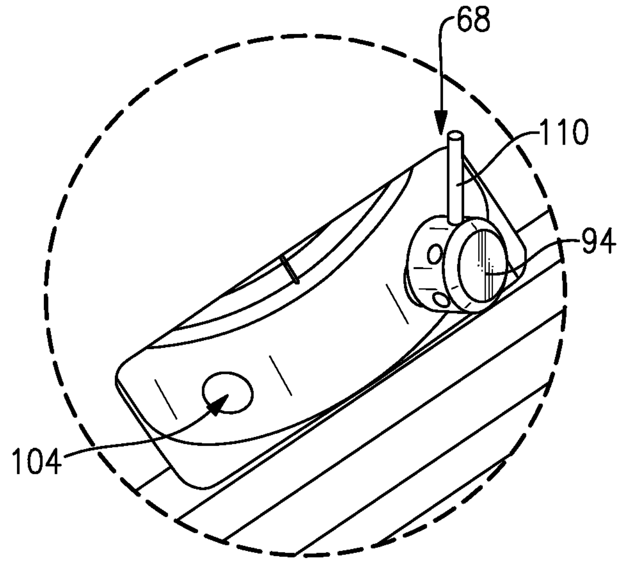
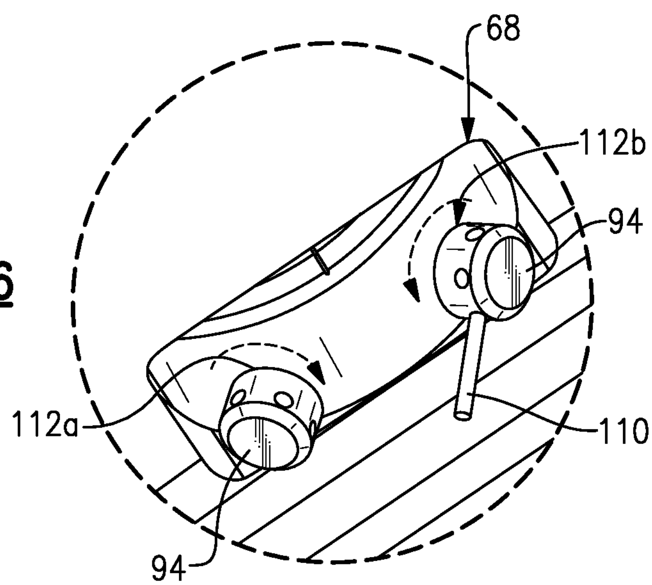


FIG.6



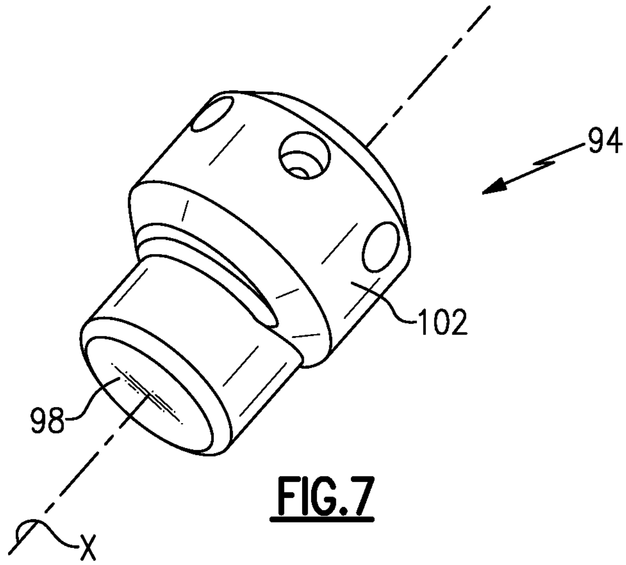


FIG.7

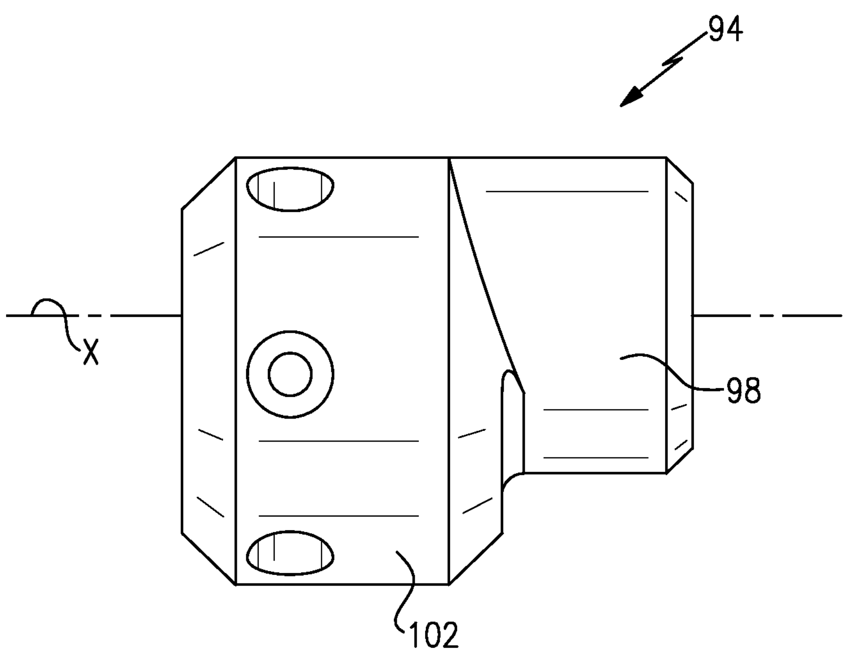


FIG.8

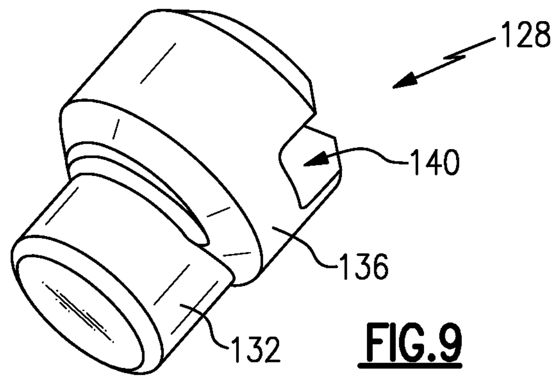


FIG.9

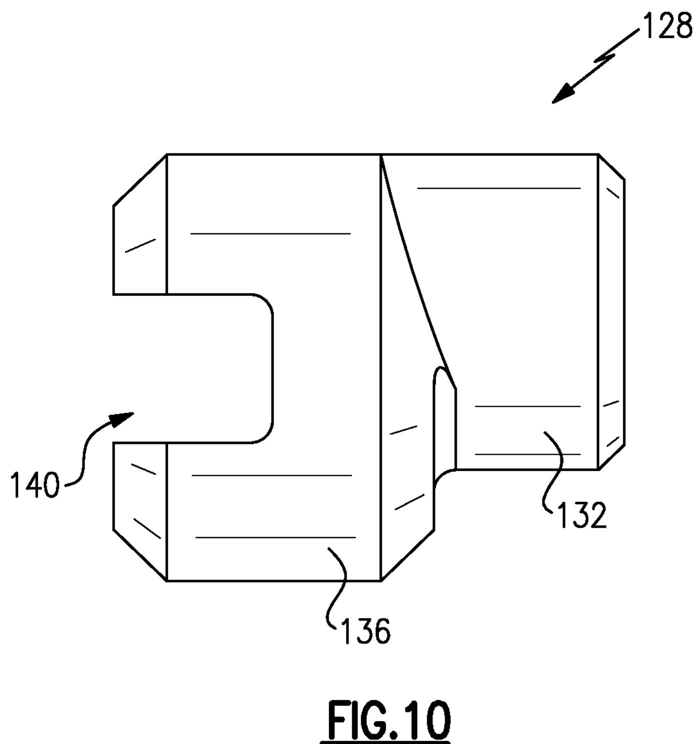


FIG.10

TURBOMACHINE PROBE RETENTION FEATURE

BACKGROUND

This disclosure relates generally to retaining a probe and, more particularly, to a secondary retention feature for retaining a turbomachine probe

Turbomachines, such as gas turbine engines, typically include a fan section, a compression section, a combustion section, and a turbine section. Turbomachines may employ a geared architecture connecting portions of the compression section to the fan section.

The turbomachine includes annular case structures that, for example, circumscribe rotatable arrays of blades. The turbomachine may include probes mounted to the case structures. The probes in some examples, may monitor a distance between tips of the blades and the associated case structure. Probes can be welded to the case structures. If the welds fail, the probes may fall into a gas path of the turbomachine, which can cause damage.

SUMMARY

A turbomachine probe assembly according to an exemplary aspect of the present disclosure includes, among other things, a probe body extending along a probe axis from a first sensor end to an opposing, second end. An eccentric retention feature is configured to engage the probe body and to contact a wall having an aperture that receives the probe body. The eccentric retention future limits movement of the probe body along the probe axis relative to the wall.

In a further nonlimiting embodiment of the foregoing turbomachine probe assembly, the first sensor comprises a lip, and the wall is held between the lip and the eccentric retention feature.

In a further nonlimiting embodiment of either of the foregoing turbomachine probe assemblies, the eccentric retention feature comprises a post that is received within an aperture provided by the probe body. The post extends to an eccentric lobe of the eccentric retention feature.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the probe body is welded to the wall.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the wall is an annular wall, and the eccentric retention feature is configured to contact an outwardly facing surface of the annular wall.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the eccentric retention feature includes apertures configured to receive a post that rotates the eccentric retention feature.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the eccentric retention feature is welded to the probe body when the probe body is in an installed position.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the eccentric retention feature includes an eccentric lobe that directly contacts the wall when the probe body is in an installed position.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the wall is within a compressor section of a turbomachine.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the probe is a capacitance probe.

In a further nonlimiting embodiment of any of the foregoing turbomachine probe assemblies, the probe is configured to determine a distance between a sensor end of the probe and a tip of a turbomachine blade.

A turbomachine compressor case assembly according to an exemplary aspect of the present disclosure includes, among other things, an annular compressor case disposed about a rotational axis A of a turbomachine. A plurality of probe assemblies each have a main body portion, a lip portion, and at least one eccentric retention feature. The main body portion is received within a respective aperture of the annular compressor case. The eccentric retention feature engages the main body portion such that a portion of the annular compressor case is positioned radially between the eccentric retention feature and the lip portion to limit radial movement of the probe.

In a further nonlimiting embodiment of the foregoing turbomachine compressor case assembly, the plurality of probe assemblies each house capacitance sensors configured to monitor variations in a radial distance between the plurality of probe assemblies and a tip of a compressor blade.

In a further nonlimiting embodiment of either of the foregoing turbomachine compressor case assemblies, the plurality of probe assemblies are welded to the annular compressor case.

In a further nonlimiting embodiment of any of the foregoing turbomachine compressor case assemblies, the at least one eccentric retention feature is welded to the main body portion of the respective one of the plurality of probe assemblies.

In a further nonlimiting embodiment of any of the foregoing turbomachine compressor case assemblies, each of the plurality of probe assemblies includes two eccentric retention features.

A method of retaining a probe within a turbomachine according to another exemplary aspect of the present disclosure includes, among other things, inserting a probe body within an aperture of a turbomachine case, and capturing a portion of the turbomachine case between a lip of the probe body and an eccentric retention feature engaging the probe body.

In a further nonlimiting embodiment of the foregoing method of retaining a probe, the method includes welding the probe body to the turbomachine case.

In a further nonlimiting embodiment of either of the foregoing methods of retaining a probe body, the capturing comprises rotating the eccentric retention feature to a position where an eccentric lobe of the eccentric retention feature contacts the turbomachine case.

In a further nonlimiting embodiment of any of the foregoing methods of retaining a probe body, the method includes welding the eccentric retention feature to the probe body after the capturing.

DESCRIPTION OF THE FIGURES

The various features and advantages of the disclosed examples will become apparent to those skilled in the art from the detailed description. The figures that accompany the detailed description can be briefly described as follows:

FIG. **1** shows an example turbomachine.

FIG. **2** shows and aft view of a compressor case of the FIG. **1** turbomachine.

FIG. **3** shows a section view at line **3-3** in FIG. **2**.

FIG. **4** shows a view at direction R in FIG. **2**.

FIG. **5** shows a perspective view of a probe area of the FIG. **2** compressor case with one eccentric retention feature partially installed.

FIG. **6** shows the view of FIG. **5** with the eccentric retention features rotated to an installed position.

FIG. **7** shows a perspective view of the eccentric retention feature.

FIG. **8** shows a side view of the eccentric retention feature of FIG. **7**.

FIG. **9** shows a perspective view of another example eccentric retention feature.

FIG. **10** shows a side view of the eccentric retention feature of FIG. **9**.

DETAILED DESCRIPTION

FIG. **1** schematically illustrates an example turbomachine, which is a gas turbine engine **20** in this example. The gas turbine engine **20** is a two-spool turbofan gas turbine engine that generally includes a fan section **22**, a compression section **24**, a combustion section **26**, and a turbine section **28**.

Although depicted as a two-spool turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with turbofans. That is, the teachings may be applied to other types of turbomachines and turbine engines including three-spool architectures. Further, the concepts described herein could be used in environments other than a turbomachine environment and in applications other than aerospace applications.

In the example engine **20**, flow moves from the fan section **22** to a bypass flowpath. Flow from the bypass flowpath generates forward thrust. The compression section **24** drives air along the core flowpath. Compressed air from the compression section **24** communicates through the combustion section **26**. The products of combustion expand through the turbine section **28**.

The example engine **20** generally includes a low-speed spool **30** and a high-speed spool **32** mounted for rotation about an engine central axis A. The low-speed spool **30** and the high-speed spool **32** are rotatably supported by several bearing systems **38**. It should be understood that various bearing systems **38** at various locations may alternatively, or additionally, be provided.

The low-speed spool **30** generally includes a shaft **40** that interconnects a fan **42**, a low-pressure compressor **44**, and a low-pressure turbine **46**. The shaft **40** is connected to the fan **42** through a geared architecture **48** to drive the fan **42** at a lower speed than the low-speed spool **30**.

The high-speed spool **32** includes a shaft **50** that interconnects a high-pressure compressor **52** and high-pressure turbine **54**.

The shaft **40** and the shaft **50** are concentric and rotate via bearing systems **38** about the engine central longitudinal axis A, which is collinear with the longitudinal axes of the shaft **40** and the shaft **50**.

The combustion section **26** includes a circumferentially distributed array of combustors **56** generally arranged axially between the high-pressure compressor **52** and the high-pressure turbine **54**.

In some non-limiting examples, the engine **20** is a high-bypass geared aircraft engine. In a further example, the engine **20** bypass ratio is greater than about six (6 to 1).

The geared architecture **48** of the example engine **20** includes an epicyclic gear train, such as a planetary gear system or other gear system. The example epicyclic gear train has a gear reduction ratio of greater than about 2.3 (2.3 to 1).

The low-pressure turbine **46** pressure ratio is pressure measured prior to inlet of low-pressure turbine **46** as related to the pressure at the outlet of the low-pressure turbine **46** prior to an exhaust nozzle of the engine **20**. In one non-limiting embodiment, the bypass ratio of the engine **20** is greater than about ten (10 to 1), the fan diameter is significantly larger than that of the low pressure compressor **44**, and the low-pressure turbine **46** has a pressure ratio that is greater than about 5 (5 to 1). The geared architecture **48** of this embodiment is an epicyclic gear train with a gear reduction ratio of greater than about 2.5 (2.5 to 1). It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present disclosure is applicable to other gas turbine engines including direct drive turbofans.

In this embodiment of the example engine **20**, a significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section **22** of the engine **20** is designed for a particular flight condition—typically cruise at about 0.8 Mach and about 35,000 feet. This flight condition, with the engine **20** at its best fuel consumption, is also known as "Bucket Cruise" Thrust Specific Fuel Consumption (TSFC). TSFC is an industry standard parameter of fuel consumption per unit of thrust.

Fan Pressure Ratio is the pressure ratio across a blade of the fan section **22** without the use of a Fan Exit Guide Vane system. The low Fan Pressure Ratio according to one non-limiting embodiment of the example engine **20** is less than 1.45 (1.45 to 1).

Low Corrected Fan Tip Speed is the actual fan tip speed divided by an industry standard temperature correction of Temperature divided by 518.7 ^0.5. The Temperature represents the ambient temperature in degrees Rankine. The Low Corrected Fan Tip Speed according to one non-limiting embodiment of the example engine **20** is less than about 1150 fps (351 m/s).

Referring now to FIGS. **2** to **6** with continuing reference to FIG. **1**, an example case is a compressor case **60** from the high-pressure compressor section **52** of the engine **20** circumscribes a compressor blade array **64**. For clarity, the compressor blade array **64** is shown in broken line form in FIG. **2**.

The compressor case holds multiple probe assemblies **68** within respective apertures **72** of the compressor case **60**. The probe assemblies **68** include sensors **76** that monitor a distance D between tips **80** of blades within the array **64** and the sensor **76**. The distance D is monitored during operation of the engine **20**. Identifying changes in the distance is useful as is known. Identifying changes in the distance D may identify areas having unacceptable wear and/or performance. The sensors **76** are capacitance sensors in this example.

The sensors **76** may be linked to a controller **82** that calculates the distance D based on the measured capacitance.

Each of the probe assemblies **68** includes a probe body **84** extending from a first sensor end **86** to an opposing second end **88**. The first sensor end **86** includes a sensor face **76** and a lip **90**. The second end **88** is connected to the controller **82**.

When installing the probe assemblies **68** to the case **60**, the probe assemblies **68** are inserted through the aperture **72**, moving in a radially outboard direction, until the lip **90** contacts the case **60**. The case **60** is an example wall of the engine **20**. A fixture (not shown) may be used to hold the probe assembly **68** in a position where the lip contacts the case **60**. A spot weld **92***a* and **92***b* are then applied to hold the probe assembly **68** within the aperture **72**. In this example, the spot welds **92***a* and **92***b*, are considered a primary retention feature associated with the probe assembly **68**.

After securing the probe assembly **68** via the welds **92***a* and **92***b*, at least one secondary retention feature **94** is added to the probe assembly **68**. The secondary example retention feature **94** is an eccentric retention feature and includes a post **98** extending along an axis X from an eccentric lobe **102**.

The secondary retention feature **94** is installed within the probe assembly **68** by inserting the post **98** into an aperture **104** of the probe body. A tool **110** is then inserted into one of a plurality of apertures **114** within the eccentric lobe **102**. The tool **110** is used to rotate the secondary retention feature **94** about an axis X of the post **98** from the partially installed position shown in FIG. **5** to the fully installed position of FIG. **6**. In the fully installed position, the eccentric lobe **102** contacts an outwardly facing surface of the case **60**.

The eccentric lobe **102** allows the secondary retention feature **94** to accommodate variations due to tolerance stacks, etc. For example, if the radial distance between the aperture **104** and the case **60** is relatively large, the secondary retention feature **94** is rotated further about the axis X until the eccentric lobe **102** contacts the case **60**.

To complete installation of the secondary retention feature **94**, spot welds **112***a* and **112***b* are applied when the eccentric lobe **102** contacts the case **60**. Welding the secondary retention feature **94** holds the rotational position of the secondary retention feature **94**. In this rotational position, contact between the secondary retention feature **94** and the case **62** prevent the probe assembly **68** for moving radially inward (in the direction R) through the aperture **72** should the spot welds **92***a* and **92***b* fail.

In the example probe assembly **68**, two of the secondary retention features **94** are used. Both of which are located in an aft portion of the probe assembly **68** relative to a direction of flow through the engine **20**. The example case **60** has a wall **118** extending aft to contact another axially adjacent case. A leading edge **120** of the example case **60** lacks such a wall and is open to a gas flow path through the engine **20** (due to, for example, a bleed cavity). Positioning the secondary retention features **94** in the aft portion ensures that, should be secondary retention features **94** become disengaged from the probe body **84**, movement of the secondary retention features **94** into the gas flow path is blocked by at least the wall **118**. The secondary retention features **94** may be placed in the leading portion in another example.

Referring to FIGS. **9** and **10**, another example secondary retention feature **128** includes a post **132** and an eccentric lobe **136**. The eccentric lobe **136** of the secondary retention feature **128** includes a slot **140**, which is used in place of the apertures **114** and tool **110**. The slot **140** receives a bladed tool, such as a screwdriver, to rotate the secondary retention feature **128** about an axis X, between a position where the eccentric lobe **136** is spaced from the case **60** and the fully installed position where the eccentric lobe **136** contacts the case **60**.

In some examples, the secondary retention feature **128** is used in areas of the engine **20** where the "end" of the secondary retention feature **128** is more accessible than the side. The secondary retention feature **94** is used in areas of the engine **20** where the "side" of the secondary retention feature **94** is more accessible than the end.

The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. Thus, the scope of legal protection given to this disclosure can only be determined by studying the following claims.

We claim:

1. A turbomachine probe assembly, comprising:

a probe body extending along a probe axis from a first sensor end to an opposing second end; and

an eccentric retention feature including a post extending along a retention feature axis from an eccentric lobe that is offset from the post, the eccentric retention feature configured to engage the probe body and to contact a wall having an aperture that receives the probe body, wherein the eccentric retention feature is rotatable against the wall about a retention feature axis to limit movement of the probe body along the probe axis relative to the wall, the probe axis transverse to the retention feature axis.

2. The turbomachine probe assembly of claim **1**, wherein the first sensor end comprises a lip, and the wall is held between the lip and the eccentric retention feature.

3. The turbomachine probe assembly of claim **1**, wherein the probe body is welded to the wall.

4. The turbomachine probe assembly of claim **1**, wherein the wall is an annular wall, and the eccentric retention feature is configured to contact an outwardly facing surface of the annular wall.

5. The turbomachine probe assembly of claim **1**, wherein the eccentric retention feature includes apertures configured to receive a tool that rotates the eccentric retention feature.

6. The turbomachine probe assembly of claim **1**, wherein the eccentric retention feature is welded to the probe body when the probe body is in an installed position.

7. The turbomachine probe assembly of claim **1**, wherein the eccentric lobe directly contacts the wall when the probe body is in an installed position.

8. The turbomachine probe assembly of claim **1**, wherein the wall is within a compressor section case of a turbomachine.

9. The turbomachine probe assembly of claim **1**, wherein the probe is a capacitance-based clearance probe.

10. The turbomachine probe assembly of claim **9**, wherein the probe is configured to determine a distance between the sensor end of the probe and a tip of a turbomachine blade.

11. A turbomachine compressor case assembly, comprising:

an annular compressor case provided about a rotational axis of a turbomachine; and

a plurality of probe assemblies each having

a main body portion,

a lip portion,

at least one eccentric retention feature including a post extending along a retention feature axis from an eccentric lobe that is offset from the post, wherein the main body portion is received within a respective aperture of the annular compressor case, and the at least one eccentric retention feature engages the main body portion such that a portion of the annular compressor case is positioned radially between the eccentric retention feature and the lip portion, the eccentric retention feature being rotatable against the annular compressor case about a retention feature axis to limit radial movement of the probe in a radial direction, the retention feature axis transverse to the radial direction.

12. The turbomachine compressor case assembly of claim **11**, wherein the plurality of probe assemblies each house capacitance sensors configured to monitor variations in a radial distance between the plurality of probe assemblies and the tips of compressor blades.

13. The turbomachine compressor case assembly of claim **11**, wherein the plurality of probe assemblies are welded to the annular compressor case.

14. The turbomachine compressor case assembly of claim **11**, wherein the at least one eccentric retention feature is welded to the main body portion of the respective one of the plurality of probe assemblies.

15. The turbomachine compressor case assembly of claim **11**, wherein each of the plurality of probe assemblies includes two eccentric retention features.

16. A method of retaining a probe within a turbomachine, comprising:

inserting a probe body within an aperture of a turbomachine case;

capturing a portion of the turbomachine case between a lip of the probe body and an eccentric retention feature engaging the probe body; and

rotating the eccentric retention feature against the turbomachine case about a retention feature axis to hold the probe body relative to the turbomachine case along a longitudinal axis of the probe body, wherein the eccentric retention feature includes a post extending along the retention feature axis from an eccentric lobe that is offset from the post, wherein the retention feature axis is transverse to the longitudinal axis of the probe body.

17. The method of claim **16**, including welding the probe body to the turbomachine case.

18. The method of claim **16**, wherein the capturing comprises rotating the eccentric retention feature to a position where the eccentric lobe of the eccentric retention feature contacts the turbomachine case.

19. The method of claim **18**, including welding the eccentric retention feature to the probe body after the capturing.

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